INTRODUCTION:
Orthopaedic surgeons have focused on improving the functional and structural outcomes of arthroscopic rotator cuff repair and labral repair through the development of biomechanically superior surgical techniques such as double-row fixation, suture-bridge fixation, and compression double-row fixation. To obtain the maximum benefit from these repair techniques, secure knot tying is necessary. The purpose of this study was to investigate the mechanical characteristics of arthroscopic knots, focusing on the effect of tying additional reversed half hitches on alternating posts (RHAPs) during knot tying.

METHODS:
(Experiment 1) Three sliding arthroscopic knots (Tennessee slider, Duncan loop, SMC knot) and three non-sliding arthroscopic knots (Revo knot, Rotator Cuff knot, Surgeon’s knot) were tied with No. 2 FiberWire (Arthrex, Naples, FL) between two rods 1 cm apart using a knot pusher. Each knot and set of rods was mounted on a materials testing machine (AG-1; Shimadzu, Kyoto, Japan). Ultimate load to failure was evaluated at a crosshead speed of 1 mm/s for 10 knots of each knot type. Failure mode was also recorded.

(Experiment 2) When suture slippage was seen in at least 1 of the 10 knots in experiment 1, a reversed half hitch on alternating posts was added, and the knots were tested again. Additional RHAPs were added until suture breakage occurred in 10 consecutive tests. The number of additional RHAPs and the final ultimate load to failure were recorded for each type of knot.

Statistical analysis: One-way analysis of variance (ANOVA) followed by Tukey’s post-hoc test was performed to compare ultimate load to failure among the 6 types of knots (P<0.05).

RESULTS:
(Experiment 1) The average ultimate loads to failure were 30 N for Tennessee slider, 36 N for Duncan loop, 46 N for SMC knot, 215 N for Revo knot, 241 N for Rotator Cuff knot, and 290 N for Surgeon’s knot. The average ultimate loads to failure of the sliding knots were significantly smaller than those of the non-sliding knots (P<0.01) (Fig. 1).

For all 3 types of sliding knots, suture slippage occurred in all 10 tests, while 7 of 10 Revo knots and 5 of 10 Rotator Cuff knots exhibited suture slippage. The Surgeon’s knots failed by suture breakage in all 10 tests.

(Experiment 2) Four additional RHAPs were required for all three sliding knots and 1 additional reversed half hitch on alternating posts was required for the Revo knot and Rotator Cuff knot before the knots failed by suture breakage in 10 consecutive tests. The final average ultimate load to failure was similar for all 6 knots (304 N for Tennessee slider, 321 N for Duncan loop, 298 N for SMC knot, 292 N for Revo knot, 292 N for Rotator Cuff knot, 290 N for Surgeon’s knot) (Fig. 2).

All the sliding knots with 2 or fewer additional reversed half hitches failed by suture slippage. After 3 additional RHAPs, 5 of 10 Tennessee sliders, 6 of 10 Duncan loops, and 5 of 10 SMC knots exhibited suture slippage. After 4 additional RHAPs, all sliding knots exhibited suture breakage without slippage (Fig. 3).

DISCUSSION:
In the literature, 2 or 3 additional RHAPs are recommended when using No. 1 PDS II or No. 2 Ethibond suture. In this study, all 3 sliding knots without additional RHAPs had poor knot security. The addition of 4 RHAPs improved the knot security of all the sliding knots tested. Although non-sliding knots provided better knot security than sliding knots, one additional reversed half hitch on alternating posts was required for the Revo knot and Rotator Cuff knot to improve ultimate load to failure beyond the failure strength of No. 2 FiberWire.

This study suggests that additional reversed half hitches on alternating posts are necessary to improve the strength of arthroscopic knots, particularly when a sliding knot is chosen.

SIGNIFICANCE:
This mechanical testing study demonstrates that additional reversed half hitches on alternating posts are necessary to improve the strength of arthroscopic knots, particularly when a sliding knot is chosen.

REFERENCES: